IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
APPLICATION FOR PATENT

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TITLE OF INVENTION: METHOD AND APPARATUS FOR AUTOMATICALLY REMOVING ZINC FROM GALVANIZING SKIMMINGS

BACKGROUND OF THE INVENTION

Applicant hereby claims the benefit of United States Provisional Application No. 60/415,172, filed on September 30, 2002 by David Jaye and entitled Method and Apparatus for Automatically Removing Zinc from Galvanizing Skimmings, which Provisional Application is incorporated herein by reference for all purposes.

Field of the Invention

This invention relates generally to methods and apparatus for reduction of ash generated during the hot dip galvanizing process which in turn reduces significantly the amount of zinc consumed during the same process. The invention also reduces emissions (smoke) which are produced during the galvanizing process, and should offer significant benefits as a method of emissions reduction. The present invention offers a method of ash reduction and zinc recovery which is automated, reducing labor.

Description of the Prior Art

The Process:

The hot dip galvanizing process is a method of metallurgically alloying zinc to the outer surface of steel for the purpose of corrosion protection. The process involves taking the metal, typically steel, through several galvanizing steps as follows:

1. **Rack-up** - Material is placed in tubs, racks or other fixtures to facilitate it to be carried through several process tanks.

2. **Caustic** - Material is dipped into a bath of liquid caustic cleaner to remove oil, paint, grease, etc. Tank is usually heated to at least 160 Deg, F.

3. **Rinse** - Residual caustic is removed in water rinse bath.

4. **Pickling** - Material is dipped into acid solution to remove rust, oxides, and mill scale. Most common acids used are hydrochloric and sulfuric.

5. **Rinse** - Residual acid is removed in water rinse bath.

6. **Pre-flux** - Materials are dipped into a solution of zinc ammonium chloride to coat material prior to molten zinc bath. This will aid in keeping materials from oxidizing while waiting to go into zinc bath.

7. **Zinc bath** - Material is dipped into a bath of molten zinc. This is where the galvanizing takes place. It is also where the ash is created. The bath temperature is usually maintained around 840 Deg. F., although temperature ranges may be from 825 to 860 Deg. F. Water quench - This step is optional. Material is quenched in a water solution to cool material for handling.

In the hot dip galvanizing industry, there exists a need to remove and reduce the ash which is produced during the galvanizing process. Currently, there are several methods typically used to reduce the zinc content in ash, and remove the ash from the molten zinc surface. The ash is generated in two ways: 1) a fluxing compound is spread over one end of the zinc bath to create a "flux blanket"", which the steel is lowered through as it is being submerged into the molten zinc to be galvanized. As the usable chemicals in the flux blanket are consumed during the galvanizing process, the flux blanket is slowly disposed of in the form of ash, and the skimming process which clears away the flux prior to withdrawal of the steel from the zinc bath also produces zinc oxide as the molten zinc comes in contact with the surrounding air. 2) A "pre-

flux" is coated onto the surface of the steel prior to being submerged into the molten zinc to be galvanized. The flux reacts to the high temperature of the zinc bath and alloying which takes place as the steel is galvanized, resulting in the formation of ash which floats to the surface of the molten zinc bath, and the skimming process which clears away the ash prior to the withdrawal of the steel from the zinc bath also produces zinc oxides.

The most common way of dealing with the ash is to skim it to one end of the kettle, and using a "dam", hold the skimmings from floating back over the surface of the molten zinc. The dam may be fashioned is several ways, one of the most common being a simple rod or pipe laid across the top of the kettle with a plate, usually steel, attached to the rod or pipe in such a way as to allow it to hang downward into the zinc bath a couple of inches, thus creating a dam which is raised and lowered (usually by one or two workers by hand) to allow the ash to be moved along the surface of the molten zinc to the other side of the dam. If a zinc and ash recovery system is not employed on a galvanizing kettle, the galvanizing skimmings are typically removed from the collection region defined by the dam and are transferred to receptacles, such as drums. Since the galvanizing skimmings contain a substantial quantity of zinc, the drums of galvanizing skimmings are periodically transferred to a zinc recovery facility where the zinc and ash are separated by subsequent processing.

Devices known in the trade as "ash boxes" are provided, which usually consist of a four sided open bottomed steel box which is suspended on the top of a galvanizing kettle at a height that allows the lower two inches or so of the walls to be submerged below the surface of the zinc bath. Thus, the molten zinc of the galvanizing bath is present within the ash box and is at the same level as the molten zinc externally of the ash box. The galvanizing skimmings are lifted over the side walls of the ash box and dropped into the box from the typically open top. At times

a removable closure for the open top is used to minimize liberation of smoke and other emissions into the surrounding atmosphere. These methods are labor intensive, quite slow, produce a lot of smoke emissions, and have inconsistent results as for zinc removal from ash and overall ash reduction.

SUMMARY OF THE INVENTION

It is the principle feature of the present invention to provide a novel method and apparatus for the removal and reduction of zinc and ash (sometimes referred to as "dry skimmings or skimmings) which forms at the surface of the galvanizing kettle zinc bath.

It is also a feature of the invention to be comprised of three "chambers" and a final receiving bin for refined ash. It is an even further feature of the invention to provide a novel method automatically reducing, conveying, and recovering zinc and ash from the galvanizing process in such a manner as to require a minimal amount of labor with consistently good results.

It is another feature of the present invention to provide a novel ash removal and zinc recovery system for hot dip galvanizing systems which effects recovery of virtually all of the zinc of the skimmings and also results in refined ash that is substantially free of zinc and this is suitable for sale as a by-product of the galvanizing process.

Briefly, in accordance with the principles of the present invention, the apparatus, which may be made of steel, is positioned at the galvanizing bath in such a way as to allow a portion of the chamber to be submerged under the surface of the molten zinc. The ash is to be put into the first chamber (a receiving chamber) which then conveys the ash into a second chamber, where the ash is "cooked" or agitated by a series of paddles which turn on a shaft inside the chamber, which is comprised of four sides (which are submerged under the zinc bath) and a top, thus allowing the free zinc which is bound to the ash to be re-melted and flow back into the zinc bath through the bottom (which is open to the zinc bath), thus removing most of the zinc from the ash.

The "cooked" ash is then removed from the second chamber via a conveyor which moves the "cooked" ash to a separation chamber (the third chamber). In this chamber the ash is placed on a device which will allow only particles of a predetermined size pass through, with the remaining particles (which is usually comprised of mostly zinc) to be conveyed back to the second chamber for more complete melting of zinc particles. The system may be totally enclosed as not to allow any fugitive emissions to be released into the surrounding atmosphere. The particles which pass through the system (refined ash) are then conveyed to a collection bin where the collected refined ash can be periodically removed and sold as a by-product of the galvanizing process.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

Referring now to the drawings and first to Fig. 1, a galvanizing bath, which may be of conventional nature, is shown generally at 10. In Fig. 1 the galvanizing bath 10 is shown to have in assembly therewith an ash removal and zinc recovery system embodying the principles of the present invention and being shown generally at 14. The galvanizing bath 10 defines a receptacle or kettle 12 within which molten zinc or zinc alloy is maintained within a proper temperature range for galvanizing parts or objects, typically composed of steel, that have been treated in accordance with the galvanizing process that is set forth herein.

The ash removal and zinc recovery system 14 includes an integral ash and zinc separator unit shown generally at 15, which includes a housing defining a first chamber 16 and a second chamber 17. The first chamber 16 is open at the top or is provided with a closure member to permit galvanizing bath skimmings containing zinc oxide ash which is laden with a small quantity of free zinc, to be deposited within the first chamber after removal of the skimmings from the galvanizing kettle 12, typically by a manual skimming operation. The first and second chambers 16 and 17 are defined by the integral zinc and ash separator unit which is shown in

greater detail in Figs. 3 and 4. The housing of the integral zinc and ash separator unit 15 is defined by parallel side walls 18 and 19 which extend the length of the unit, with end walls 20 and 21 defining respective ends of the unit.

The housing of the integral zinc and ash separator unit 15 may also be provided with a top wall or closure 22 which may be fixed to the side walls if desired or may be removable or capable of being opened if access to the interior of the second chamber is desired for any reason. If a removable or moveable closure is employed, it will typically be substantially sealed with the side and end walls when closed. The top wall or closure 22 serves to prevent smoke or other emissions from being liberated into the atmosphere and assists in providing the processing system for the skimmings to be essentially smoke free. The integral zinc and ash separator unit 15 is supported with respect to a galvanizing kettle by a plurality of support members 24 which project from the side or end walls and rest on upper edge portions of a galvanizing bath structure as shown in Figs. 2 and 3. This feature readily adapts the zinc and ash removal apparatus of the present invention for use with existing galvanizing kettles.

The first chamber may have a cover 26 which is closed or replaced after skimmings have been removed from the galvanizing bath and deposited within the first chamber, though the presence of a cover is not mandatory. A cover for the first or skimmings receiving chamber, however, assists in maintaining the "smoke free" character of the processing unit for the skimmings.

An intermediate wall 25 which is welded or otherwise attached to the side walls 17 and 19, forms a partition between the first and second chambers. The first chamber 16 is defined in part by tapered bottom wall sections 27 which converge to a bottom conveyance opening 28 of a tubular member or conveyor housing 29 that is disposed in fixed relation with the intermediate

wall 25. The conveyor housing 29 is preferably of circular internal cross-sectional configuration though it may be of other configuration if desired.

The first chamber 16, which primarily receives the skimmings of the galvanizing kettle, is provided with a rotary conveyor 30 which is located at the narrow bottom of the first chamber and at least partially within the conveyor housing 29 and cooperates with the internal cylindrical wall of the conveyor housing to substantially effect a seal within the conveyor housing and thus define a smoke barrier to prevent smoke within the second chamber from flowing to the first chamber. Smoke and other emissions are typically present in the second chamber due to processing or "cooking" of the ash and zinc skimmings for melting or recovery of the zinc content of the skimmings. The conveyor 30 is energized by a first drive motor 31, preferably an electric rotary motor, which drives a reduction gear mechanism 32, which in turn drives a conveyor shaft 33. The conveyor 30, may be of any suitable type, but is preferably in the form of a helical screw conveyor which conveys skimmings from the first chamber through the tubular conveyor housing and deposits the skimmings into the skimmings receiving end or region of the second chamber 17 via a conveyor discharge opening 34. The second chamber 17 is of elongate configuration defining a skimmings receiving region at one end thereof and an ash discharge region at the opposite end.

The second chamber structure 17 has an open bottom, with the side walls 18 and 19 and the end walls 20 and 21 extending below the surface of the molten zinc and effecting a liquid seal with the zinc that prevents smoke within the second chamber 17 from being liberated into the atmosphere. Within the second chamber 17 is a rotary agitator shaft 35 which extends the length of the second chamber from the skimmings inlet end to the ash discharge end and has driven relation with the helical conveyor 30. The agitator shaft 35 may be integral with the

helical screw conveyor 30 or may be non-rotatably connected to the helical screw conveyor so that the conveyor and the shaft rotate in unison. The agitator shaft 35 is thus preferably driven by the rotary drive motor 31 and reduction gear mechanism 32, though it can be driven by an independent rotary motor if desired.

The driven agitator shaft 35 is rotatably supported at one end by a bearing 36 and is provided with a plurality of paddle elements 37 which are of such length that a portion of each paddle passes below the surface "S" of the molten zinc 38 of the galvanizing kettle within the second chamber 17 during each revolution of the driven agitator shaft 35. The paddle elements basically slowly agitate the skimmings within the second chamber 17 and cause zinc particulate entrained within the ash content of the skimmings to descend by gravity and by the motive force of the paddles into the molten zinc, where the zinc particles are melted and are thus returned to the zinc bath. It should be borne in mind that the agitation of the ash and zinc skimmings is gentle as the paddle elements 37 are slowly rotated by the agitator shaft 35 so that the skimmings are slowly "folded" into the molten zinc and melted and the ash content of the skimmings rises and floats on the surface of the molten zinc.

Since the ash and zinc particulate within the second chamber are prevented by the intermediate wall or partition 25 from returning to the first chamber, substantially continuous supply of skimmings into the second chamber and the rotary motion of the paddles and the paddles will provide gentle motive force causing movement of the ash content toward an ash discharge region, at or near the opposite end wall 20 of the second chamber to a discharge opening 39 in the end wall 20. Preferably, the paddles 37 will have a slightly inclined orientation and thus will function as impellers to apply a lateral motive force to the skimmings and thus move the skimmings from the inlet region of the second chamber to its outlet or

discharge region. During paddle induced movement of the skimmings along the surface of the molten zinc within the second chamber, the skimmings will additionally be substantially rotated on or in the surface of the molten zinc of the second chamber 17 by the rotating paddles, thus causing the skimmings to repeatedly enter the molten zinc and thus enhance melting of the zinc particulate contained therein, so that the zinc content on the skimmings is efficiently returned to the molten state and becomes part of the zinc bath. Thus, as the skimmings progress slowly from the inlet region to the outlet or discharge region of the second chamber the particulate zinc content of the ash will become less and less. The velocity of movement of the skimmings from the inlet region of the second chamber by the motive force of the paddles is designed so that the resulting processed ash at the outlet region of the second chamber will have only a minimal content of free zinc. Thus, the ash and only a small quantity of remaining zinc particulate will continuously build up within the discharge region of the second chamber until it reaches the discharge opening 39, whereupon it will be discharged from the second chamber to a pick-up or inlet 40 of a processed ash conveyor 41 that is shown in detail in Fig. 6.

The discharged ash and zinc from the second chamber will be conducted by the processed ash conveyor 41 to a separator chamber 42 which is typically located near but not above the galvanizing kettle 12. The processed ash conveyor 41 is defined by an elongate tubular conveyor housing 43 having a helical conveyor element 44 rotatable therein. The helical conveyor element 44 can be constituted by any suitable helical type or auger conveyor which is rotated within the conveyor housing by a drive motor 45 having a rotary drive shaft 46 driving a reduction gear mechanism 47 that in turn imparts rotation to a drive shaft 49 of the rotary helical conveyor element 44. The helical conveyor element 44 is preferably in the form of an elongate

flexible helical spring that extends the length of the tubular conveyor housing, thus permitting the conveyor 41 to have the form of a bend or curve, if desired, as shown in Fig. 1.

A third or separator chamber 42, as shown in Fig. 5, comprises an outer housing 50 which may be of any desired cross-sectional configuration, circular cross-section being preferable, having a side wall 51 a top wall 52 and a bottom wall 53, thus forming an essentially sealed enclosure to prevent liberation of any smoke or other gaseous constituents that might otherwise be liberated in the form of atmospheric contaminants.

Within the outer housing 50 is movably mounted an internal housing 54 which is also defined by a side wall 55 a top wall 56 and a bottom wall 57. The internal housing is mounted on posts 58 that have resilient supporting members 59, thus permitting the internal chamber 54 to be movable or free-floating within the outer housing 50. A vibrator mechanism 60 having a vibrator motor 61 is mounted to or within the inner housing 54 by a mounting bracket and is operated electrically or by any other suitable means for vibrating the internal housing. The vibrator mechanism preferably employs a rotary air driven motor which operates an eccentric weight that imparts oscillatory or vibratory motion to the internal housing. A product screen 62 is mounted transversely within the internal housing and is thus movable along with the internal housing as the vibrator mechanism is energized. The product screen 62 receives ash and zinc particulate that is discharged from the conveyor 41. A chute or tube 63 extends from the conveyor 41 through the top wall 52 to an inlet opening 64 of the top wall 56 of the internal housing 54 and conducts the ash and zinc particulate into the internal housing and onto the product screen 62.

During vibratory motion of the inner housing and the product screen 62 by the vibrator mechanism 60 the product screen 62 allows most of the powder-like zinc oxide ash to pass

through the product screen, while the larger zinc particulate content is moved along the vibrating product screen 62 to a zinc discharge opening 65 where it exits the inner housing 54 and descends via a chute or tube 66 to a conveyor pick-up receptacle 67. The separated zinc particulate and some of the larger ash particulate are then moved by a residual zinc conveyor 68 back to the second chamber through a zinc inlet opening 69 for additional processing. The residual zinc conveyor 68 may be of the same type as the conveyor 41, discussed above, and is typically operated by a rotary drive motor and reduction gear assembly 70 in similar fashion.

Within the internal housing 54 and below the product screen 62 is fixed a hopper 71 having tapered walls 72 which direct ash product falling from the product screen through a hopper discharge opening 73 to a hopper via a hopper discharge tube 74. The hopper discharge tube 74 extends through the side wall 55 of the internal housing 54 and defines a tube outlet opening 75 which directs discharged ash product to a discharge chute or tube 76 which penetrates the side wall 51 of the outer housing. The discharge tube 74 and the discharge chute or tube 76 are not physically connected, so that the vibratory action of the internal housing and thus the discharge tube 74 are not interfered with by the structural components of the outer housing. A suitable receptacle 77 may be positioned below the discharge chute or tube 76 to receive the ash product that results from the process.

To minimize the potential for liberation of smoke into the atmosphere during processing of the galvanizing skimmings for recovery of zinc and for producing a substantially zinc free ash by-product, the second chamber 17, also referred to as the skimmings processing chamber, is a closed chamber, being closed at the top, sides and ends by the housing structure and being closed at the bottom by the molten zinc of the galvanizing kettle. The processed ash chamber and the galvanizing skimmings conveyor, processed ash conveyor 41 and the residual zinc conveyor 68

are each substantially closed so that smoke therein from galvanizing skimmings is substantially prevented from being liberated into the surrounding atmosphere.

Fig. 7 illustrates the preferred embodiment of the present invention as discussed herein in connection with Figs. 1-6. Fig. 13 is a pictorial or isometric illustration of the preferred embodiment of the invention. Fig 8 discloses an alternative embodiment which differs from the ash and zinc processing system of Fig. 7 in that the integral ash and zinc separator unit 15a defines a single open bottomed galvanizing skimmings processing chamber 17a within which is located a rotary agitator shaft 35a that is mounted for rotation by bearings. The rotary shaft is mounted generally horizontally and is located above the maximum level of the molten zinc within the chamber 17a. The agitator shaft 35a is driven by a rotary drive motor 31a and reduction gear train. In this case galvanizing skimmings, removed from the surface of the molten zinc within the galvanizing kettle, typically by a manual skimming operation, will be introduced into the single chamber 17b through an opening 16a in the top wall 22a, a portion of which is shown in the figure, or through an opening in the side wall 19a. The top or side wall opening is preferably provided with a closure or door 26a that assists in preventing liberation of smoke from the single ash and zinc processing chamber 17b to the surrounding atmosphere. The galvanizing skimmings processing chamber may be of any desired configuration; however preferably it is of elongate configuration, defining a skimmings inlet region at one end thereof and a processed ash discharge region at the opposite end thereof. The paddle elements 37, though turning only a small number revolutions per minute to work the zinc component of the skimmings into the molten zinc, are slightly inclined so that the ash and retained residual zinc is propelled slowly along the length of the galvanizing skimmings processing chamber so that by

the time it reaches the processed ash discharge region the ash will have only a trace amount of residual zinc.

Referring to Fig. 9, an alternative embodiment of the present invention is shown which differs from the preferred embodiment of Figs. 1-7 in that there is a single conveyor 41b that conveys processed ash from the second chamber 17b to the third chamber 42b. In this case, any residual zinc particulate that is separated from the ash by the vibratory inner housing with its separator screen is conducted to a suitable receptacle "R", and is periodically manually dumped into the galvanizing skimmings processing chamber 17b to be further processed along with fresh galvanizing skimmings that is periodically deposited therein so that the residual zinc particulate that is separated from the ash can be returned to the molten zinc bath for recovery. According to the embodiment of Fig. 9, the ash that is separated from the residual galvanizing skimmings in the separator chamber by the vibratory screen system of the separator chamber, is deposited as refined ash in a suitable receptacle, permitting it to be sold as a by-product of the hot dip type galvanizing system.

According to the embodiment of Fig. 10, no screening system is provided and the integral ash and zinc separator unit 15c is of similar construction and function as shown in Fig. 9 with the exception that a single material outlet or exit "E" is located typically at the uppermost portion of the end wall 20c so that virtually all of the material exiting at the outlet will be ash. The zinc content of the skimmings, due to its higher specific gravity, will have been re-melted within the molten zinc of the galvanizing bath. Typically, any free zinc particulate remaining as the processed ash arrives at the ash discharge region of the galvanizing skimmings processing chamber will be caused by gravity to descend to or be located near the molten zinc surface within the galvanizing skimmings processing chamber and thus will be located below the level of

the single material discharge outlet or exit "E". This feature causes the ash being discharged from the single material outlet or exit "E" to be essentially free of zinc particulate.

Another embodiment of the present invention is shown in the plan view of Fig. 11 wherein the integral ash and zinc separator unit 15d accomplishes processing of the skimmings of a galvanizing kettle without any of the resulting ash component of the skimmings being discharged during continuous operation of the unit by the drive motor 31d. When the galvanizing skimmings processing chamber of the integral ash and zinc separator unit 15d has become filled with ash, it can be manually removed from the galvanizing kettle and the ash and any residual zinc material can be dumped either for disposal or for further processing in separately operated equipment for separating the zinc from the ash. The resulting zinc can be returned to the galvanizing kettle and the refined ash product can be packaged for disposal or for sale as a zinc oxide product that can be used in other processes.

Fig. 12 illustrates an "ash box" that represents the prior art. In this case, an open bottomed box structure is supported on a galvanizing kettle and has a rotary drive motor that rotates a shaft having paddles. The side and end walls of the open bottomed box structure project downwardly about two inches into the molten zinc of the galvanizing kettle, thus causing the molten zinc to be present to the level of the galvanizing kettle within the ash box. Skimmings from the galvanizing bath are placed within the chamber that is defined by the ash box and are agitated gently by the slowly rotating paddles of a motor driven agitator shaft. The ends paddles pass through the upper surface region of the molten zinc within the ash box and cause the zinc of the skimmings to be re-melted by the molten zinc. Periodically, the ash, which is mostly present at the upper portion of the ash box, is removed manually. Unfortunately, this type of processing equipment for the skimmings is unable to separate all of the zinc particulate

from the ash, so that there is significant zinc loss that results from its use or the ash and zinc mixture must be processed by other zinc separation systems in order to recover the zinc content. However, an ash box does provide for less loss of the zinc as compared with galvanizing systems that are operated in a manner that causes the skimmings to be collected, such as in barrels or receptacles and later treated by processing organizations that separate the zinc and ash. Though the zinc and ash is separated, it is clear that the cost of separation significantly enhances the cost of the resulting zinc component.

Fig. 13 is a pictorial illustration of an ash and zinc processing system that embodies the principles of the present invention and represents the preferred embodiment and best mode of the invention. In this case, the motors driving the various conveyors are typically rotary electric motors while at least the motor that accomplishes vibration of the internal housing of the ash and zinc separator can be a rotary air driven motor which operates an eccentric weight that impart oscillatory or vibratory motion to the internal housing and its separator screen. The embodiment of Fig. 13 is constructed according to the principles of the present invention, as shown in Figs. 1-6 hereof.

When the ash and zinc processing system is to be shut down for any period of time, to ensure that the apparatus is not fouled by solidified zinc resulting from cooling of the galvanizing system, one or more manually operated clearing devices may be employed. A rotary manually operated clearing device is shown in Fig. 13 which is rotated by a crank member “C”. The crank can be rotated manually to impart movement to components that might otherwise become fouled by solidifying zinc. The ash and zinc processing system of Figs. 1-7 and 13 includes a control system 90 having on and off switches and a timing circuit that causes operation of the conveyors for a period of time after the shut-down sequence has been initiated,

so that the apparatus can be cleared of residual skimmings that might otherwise cause fouling of the apparatus upon cooling.

The invention provides a system to reduce the amount of ash generated during the galvanizing process by removing most of the zinc which is initially in the skimmings at the time they are put into the first chamber of the device. Moreover, the galvanizing skimmings processing system of the present invention utilizes the heat of the galvanizing kettle for accomplishing recovery of the zinc component and for refining the ash component of the skimmings. A significant cost savings is realized as compared to the present method of collecting the skimmings into containers and transporting the containers to another facility for zinc recovery and for refining of the ash. The process is automated, eliminating the need for labor to manually remove the ash from the kettle, as the device conveys the galvanizing skimmings through its three chambers, returns the separated zinc to the galvanizing kettle and deposits the refined ash into a refined ash receptacle, which is emptied periodically. The entire process is substantially closed to the surrounding environment, thus performing skimmings processing with little or no liberation of smoke or other emissions. The end result is a very consistent, environmentally friendly method to reduce overall zinc consumption in the hot dip galvanizing process.